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*Indian Standard*

**METHOD FOR  
DETERMINATION OF FLOW TIME BY  
USE OF FLOW CUPS**

**( First Revision )**

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**BUREAU OF INDIAN STANDARDS  
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG  
NEW DELHI 110002**

**Gr 3**

**December 1982**

# Indian Standard

## METHOD FOR DETERMINATION OF FLOW TIME BY USE OF FLOW CUPS

### ( First Revision )

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*Indian Standard*

**METHOD FOR  
DETERMINATION OF FLOW TIME BY  
USE OF FLOW CUPS**

*( First Revision )*

**0. FOREWORD**

**0.1** This Indian Standard ( First Revision ) was adopted by the Indian Standards Institution on 12 May 1982, after the draft finalized by the Industrial Process Measurement and Control Sectional Committee had been approved by the Electrotechnical Division Council.

**0.2** This standard was first published in 1966. This revision has been undertaken to incorporate the ISO recommendation for a single improved design of flow cups in order to achieve complete rationalization through the adoption of an international standard flow cup. The determination of flow time has also been intended in this revision.

**0.3** Flow cups are used for determining the efflux time for paints, varnishes, lacquers and other viscous products by a simple empirical flow test. They consist essentially of a container of specified dimensions with an orifice through which the sample flows and the variations in the viscosity of product due to processes of blending and dilution are indicated by the variations in efflux time. Recommendations for care and checking of flow cups are given in Appendix A.

**0.4** The design adopted for the flow cups has been chosen carefully to give the best compromise between accuracy in use in the viscosity range up to 150 cSt ( centistokes ), ease of use including cleaning, and ease of manufacture. It is considered that paint materials of higher viscosities would necessarily have anomalous flow properties which cannot be properly assessed by flow cup measurement. For assessing such materials viscometers operating at high rates of shear are recommended.

**0.5** In the preparation of this standard considerable assistance has been derived from ISO 2431-1972 'Paint and varnishes — Determination of flow time by use of a flow cups', issued by the International Organization for Standardization.

**0.6** For the purpose of deciding whether a particular requirement of this standard is complied with, the final value observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960\*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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## 1. SCOPE

**1.1** This standard specifies the dimensions and the method of use of flow cup suitable for measuring the flow time of paints, varnishes and related products of newtonian and near-newtonian flow properties, of kinematic viscosity in the range of  $25 \times 10^{-6}$  to  $150 \times 10^{-6} \text{ m}^2/\text{s}$  ( 25 to 150 centistokes ).

**NOTE** — The method is only suitable when the break point of the flow of product from the orifice of the cup can be defined with certainty. For paint products, this is normally found only in paints having a kinematic viscosity of not more than 150 centistokes, such as the thinner brushing paints and those used for spraying, dipping, flow coating, etc.

## 2. TERMINOLOGY

**2.0** For the purpose of this standard, the following definitions shall apply.

**2.1 Flow Time** — The time in seconds which elapses from the moment when the material under test starts to flow from the orifice of the filled cup to the moment when the stream of material flowing out breaks.

**2.2 Newtonian Flow** — A material is considered to have newtonian flow when the ratio of the rate of shear to the shearing stress does not vary at different rates of shear. When variations in this ratio are small, the effect on viscosity of mechanical disturbance, such as stirring, is negligible and the material is said to have near-newtonian flow.

**2.3 Anomalous Flow** — A material is considered to have anomalous flow when at a constant temperature the ratio of the shear rate to the shearing stress varies either with time or with shear rate. For example, with so-called thixotropic materials, stirring or other such mechanical disturbance immediately before test will reduce the flow time below that for an unstirred sample. With such materials uncertain and variable values for flow time are obtained in all flow cups.

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\*Rules for rounding off numerical values (*revised*).

**2.4 Viscosity Units** — Absolute or dynamic viscosity is defined in newton seconds per square metre ( N·s/m<sup>2</sup> ) but for laboratory purposes it is frequently measured in poises and centipoises ( 1 cP = 10<sup>-3</sup> N·s/m<sup>2</sup> ). For the flow of liquids through tubes under gravity the density of the material shall also be taken into account. The ratio absolute viscosity/density is known as the kinematic viscosity, which is defined in square metres per second ( m<sup>2</sup>/s ) but for laboratory purposes it is frequently measured in stokes and centistokes ( 1 cSt = 10<sup>-6</sup> m<sup>2</sup>/s ). The flow time of newtonian and near-newtonian materials in flow cups is related to the kinematic viscosity.

### 3. TEMPERATURE CONSIDERATIONS

**3.1** The test temperature shall be 27°C. It is essential to use a controlled temperature enclosure or to ensure that temperature variation during testing does not exceed 0.5°C.

**NOTE** — The effect of temperature on flow time is very significant and it is for this reason that the use of a controlled temperature enclosure ( for example, a cabinet or room ) is recommended and is considered essential for international reference purposes. If this is not available, it should be ensured that the temperature change in the material during the testing, as determined by comparing the material temperature just before testing with that recorded by a thermometer in the efflux stream, shall be kept as low as possible and in any case shall not exceed 0.5°C. It is not possible to apply a general temperature correction factor to flow time because the types of materials likely to be tested are known to have very different temperature coefficients.

### 4. GENERAL AND CONSTRUCTIONAL REQUIREMENTS

#### 4.1 Flow Cup

**4.1.1 Dimensions** — The dimensions of the flow cup and the tolerances allowed in manufacture shall be as given in Fig. 1. The most critical tolerance is internal diameter of the jet of the cup since the flow time is inversely proportional to the fourth power of this dimension. The jet of the cup shall be made of stainless steel or sintered carbide, unless specified otherwise, and the body of the cup shall be made of a material which is corrosion resistant and not affected by the products to be tested.

**4.1.2 Construction** — The dimensions not specified shall be such that no distortion of the cup can occur in use. The external shape shown in Fig. 1 is recommended, but may be modified for convenience of use or manufacture, provided that the protruding jet of the cup is protected from accidental damage as far as possible by an external protective sleeve. Such a protective sleeve shall not be immediately adjacent to the jet so as to cause a capillary action when the material under test flows out.

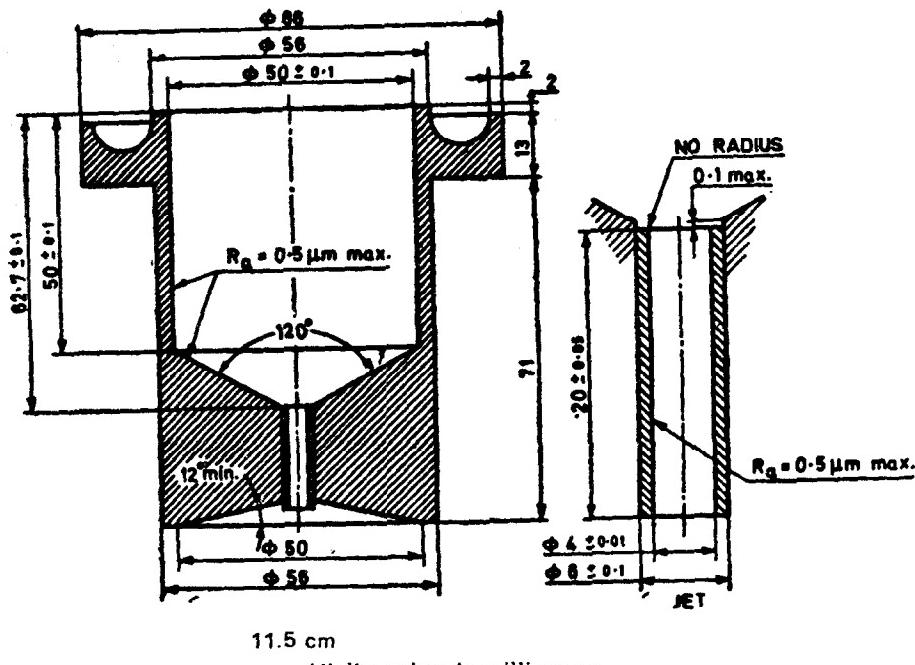


FIG. 1 FLOW CUP

**4.1.3 Finish** — The interior surfaces of the cup, including the orifice, shall be smooth and free from turning marks, crevices, ledges and burrs which may cause random flow or trap some sample or cleaning material. The standard of finish required shall be equivalent to a maximum roughness of not more than  $0.5 \mu\text{m}$  defined as the arithmetic mean deviation  $R_a$  from the mean line of the profile (*see IS : 3073-1967\**).

**4.1.4 Calibration** — The cup shall be calibrated using a standard mineral oil of known kinematic viscosity. The procedure used shall be as given in Appendix B.

## 4.2 Supplementary Apparatus

**4.2.1 Thermometer**, accurate to  $0.2^\circ\text{C}$  and graduated at  $0.1^\circ\text{C}$  intervals.

**4.2.2 Stand**, suitable for holding the flow cup and provided with leveling screws (*see also 7.2*).

\*Specification for assessment of surface roughness.

**4.2.3** Spirit level, preferably of the circular type.

**4.2.4** Flat glass plate or straight edge scraper.

**4.2.5** Stop watch or other suitable timing device with scale divisions of 0·2 second or finer and accurate to within 0·1 percent when tested over a 60 minute period.

**4.2.6** Temperature controlled room or enclosure for maintaining the cup and sample at a constant temperature.

## 5. MARKING

**5.1** Each flow cup shall be permanently and legibly marked with the followings:

- a) Identification number, and
- b) Manufacturer's name or trade-mark.

**5.1.1** The flow cups may also be marked with the Standard Mark.

NOTE — The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

## 6. SAMPLING

**6.1** A representative sample of the material to be tested shall be taken.

**6.1.1** Before testing, the sample shall be strained through a sieve of aperture size 125  $\mu\text{m}$  into a clean container. Strained material sufficient for carrying out one test shall be 150 ml. Care shall be taken to mix the paint thoroughly, while at the same time avoiding, as far as possible, loss of solvent by evaporation.

## 7. DETERMINATION OF FLOW TIME

**7.1 Temperature Adjustment** — The strained sample and the flow cup shall be adjusted to a temperature of  $27^\circ \pm 0.5^\circ\text{C}$  or to an alternate agreed test temperature. If a controlled temperature enclosure is used, as recommended, it is advisable to condition the sample before sieving, and also the cup, by placing them in the enclosure before use. The sample shall be considered ready for test immediately after any air

bubbles entrained during the preparation and sieving, procedures have dispersed. A final check that the temperature of the sample is within 0·5°C of the agreed test temperature shall be made immediately prior to filling the cup.

**7.2 Preparation of the Flow Cup** — The flow cup shall be placed on the stand provided, in a place free from draughts, and by using a spirit level and adjusting the levelling screws of the stand it shall be ensured that the upper rim of the flow cup is in a horizontal plane.

**7.3 Filling the Flow Cup** — With the orifice closed by the finger, the cup shall be filled with the freshly sieved, bubble-free sample, pouring slowly to avoid the formation of air bubbles. If any bubbles are formed, they shall be allowed to rise to the surface and removed. If the cup has been properly levelled, the sample will overflow evenly over the rim, into the gallery. Any meniscus formed shall be removed by drawing a straight edge over the entire rim of the cup or by sliding over the rim a flat glass plate with rounded edges so that no air bubbles form between the glass and the surface of the sample, and then drawing this plate horizontally across the rim of the cup so that, when it is removed, the level of the sample coincides with the top rim of the cup.

**7.4 Measurement of Flow Time** — A suitable receiver shall be placed under the flow cup so that the distance between the orifice of the flow cup and the surface of the received sample is not less than 100 mm. The finger shall be removed from the orifice simultaneously starting the timing device stopping it as soon as the first break occurs close to the orifice, in the stream of sample. The flow time shall be recorded to the nearest 0·2 second.

If the test is not carried out in a controlled temperature enclosure, a thermometer shall be placed in the stream of sample. It is convenient to use the same thermometer as used to adjust the temperature of the sample initially. This may be conveniently done by holding the thermometer in a suitable clamping device with the bulb so placed that it is at an angle to the direction of flow and completely immersed in the emergent stream. Any difference in temperature from the initially adjusted temperature shall be not greater than 0·5°C.

## 7.5 Precision

**7.5.1 Repeat Determination** — A second determination shall be carried out using another portion of the originally prepared sample and checking carefully that the temperature of testing is within the prescribed limits. The flow time in each case shall be recorded to the nearest 0·2 seconds. The results of the two determinations shall not differ from their mean value by more than 2 percent. If they do, a third determination shall be made. If the results of this determination and either one of the

previous determinations do not differ from their mean value by more than 2 percent, the other of the previous results shall be discarded. If the third determination does not provide this measure of agreement, the method of test is unlikely to be suitable because of anomalous flow behaviour, and consideration shall be given to other methods of test.

**7.5.2 Reproducibility** — Results from different laboratories shall not be considered suspect unless they differ by more than 5 percent absolute.

## 8. TEST REPORT

**8.1** The test report shall include the following information:

- a) Reference to this standard;
- b) Type and identification of the product under test;
- c) Description of the flow cup used, including identification number;
- d) Temperature of testing to the nearest  $0.2^{\circ}\text{C}$ ; and an explanation if this temperature, by agreement, differs from  $27^{\circ} \pm 0.5^{\circ}\text{C}$ ;
- e) The flow time reported as mean value ( of two results ) rounded off to the nearest second, provided that the individual results do not differ by more than 2 percent from the mean value before rounding; for reference purposes the individual values recorded to the nearest 0.2 second shall also be reported;
- f) Any deviation, by agreement or otherwise, from the test procedure described; and
- g) Date of the test.

## A P P E N D I X A

( Clause 0.3 )

### CARE AND CHECKING OF FLOW CUPS

**A-1.** The cup shall be cleaned immediately after use and before the sample starts to dry, using a suitable solvent. Metal cleaning tools or wire should never be used. If the orifice becomes contaminated with dried deposits, these should be softened with a suitable solvent and cleaned carefully, with a soft cloth pulled through the orifice.

**A-2.** Cups shall be checked periodically for wear or damage by the calibration procedure given in Appendix B.

**A P P E N D I X B**  
*( Clauses 4.1.4 and A-2 )*

**CALIBRATION PROCEDURE**

**B-1.** Cups which are dimensionally similar will give similar flow times with newtonian liquids provided the temperature of testing is precisely the same. The use of such liquids to calibrate cups provides a useful means of initially checking that dimensionally similar cups are within the accepted tolerances, and also for checking from time to time whether any wear or damage has taken place sufficient to bring a cup outside the accepted tolerances.

**B-2.** Since a liquid flows out of an orifice under its hydrostatic pressure, flow time is related to its kinematic viscosity.

**B-3.** A calibration curve relating flow time and kinematic viscosity is given in Fig. 2. This curve has been carefully constructed from flow time values determined by using different flow cups conforming to the dimensional requirements of Fig. 1. The liquids used were mineral oils of newtonian characteristics whose kinematic viscosity over a range of temperatures had been carefully determined. For the range 25 to 150 cSt, the curve corresponds closely to the equation:

$$V = 1.37t - \frac{200}{t}$$

where

$V$  = kinematic viscosity, in centistokes; and

$t$  = flow time, in seconds.

**B-4.** Using such oils a cup can be calibrated by recording the flow times of the oils at temperatures for which the kinematic viscosities are known, and comparing such flow times with the values given in Fig. 2. The cup may be deemed satisfactory for use if the method used for determination of flow time is exactly in accordance with the procedure laid down in this standard except that all temperature shall be recorded to the nearest 0.1°C, and the recorded flow time is within  $\pm$  3 percent of the corresponding value on the calibration curve. For reference purposes, however, it is advisable to apply a correction factor calculated from the deviation from the calibration curve for the cup used.

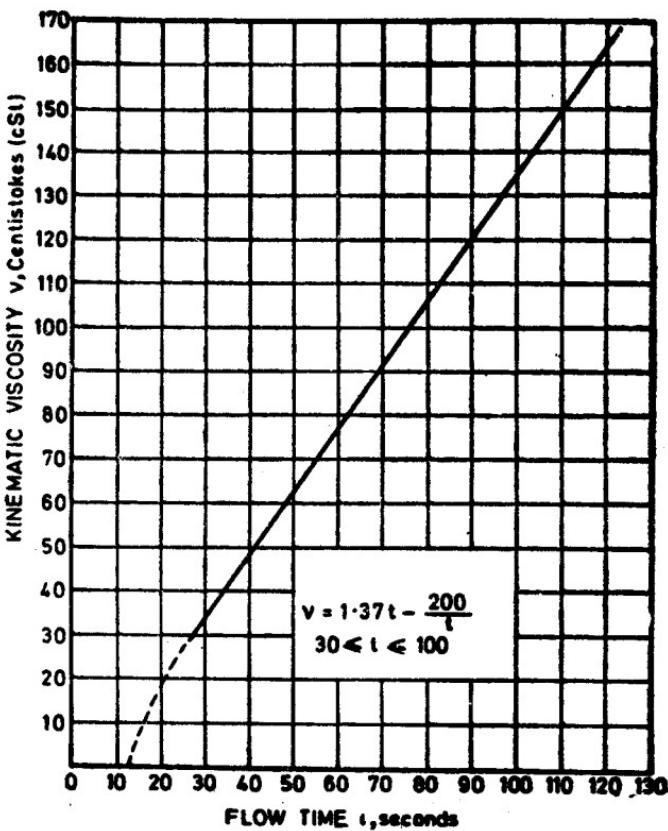


FIG. 2 CALIBRATION CURVE

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